<u>PATENT APPLICATION</u>

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

In re the Application of

Zhe-Hong CHEN et al.

Application No.: 09/939,638

Filed: August 28, 2001   Docket No.:   110468

For: IMAGE PROCESSING APPARATUS AND STORAGE MEDIUM FOR STORING
        IMAGE PROCESSING PROGRAM

<u>PRELIMINARY AMENDMENT</u>

Director of the U.S. Patent and Trademark Office
Washington, D. C. 20231

Sir:

        Prior to initial examination, please amend the above-identified application as follows:

<u>IN THE TITLE</u>:

        Please replace the title as follows:

    IMAGE PROCESSING APPARATUS AND STORAGE MEDIUM FOR STORING

                    IMAGE PROCESSING PROGRAM

<u>IN THE SPECIFICATION</u>:

        Page 1, lines 6-8, delete current paragraph and insert therefor:

        The present invention relates to an image processing apparatus for smoothing image

data and to a storage medium in which an image processing program for causing a computer

to perform such smoothing is stored.

        Page 6, lines 4-6, delete current paragraph and insert therefor:

        First to third embodiments are directed to an electronic camera that is provided with a

function of image processing that is performed by an image processing apparatus according

to the invention.

Page 9, lines 11-14, delete current paragraph and insert therefor:

In the first to third embodiments, a result of G interpolation processing or smoothing processing is set in G'[X, Y]. It is assumed that color information on the green color component G[X, Y] is set as an initial value for G'[X, Y] corresponding to a pixel in which color information on green color component exists.

Page 9, lines 19-22, delete current paragraph and insert therefor:

The operation of the first embodiment will be described below. In the following, the G interpolation processing and the smoothing processing of the image processor 11 will be described with reference to Fig. 3 and the other part of the operation will not be described.

Page 18, lines 2-9, delete current paragraph and insert therefor:

Specifically, the image processor 11 calculates a similarity degree C45[i, j] in the diagonal 45° direction and a similarity degree C135[i, j] in the diagonal 135° direction of a pixel that misses a green color component by performing weighted addition on results of weighted addition on similarity components of the pixel that misses a green color component and its surrounding pixels (e.g., C45_0[i, j], C45_0[i-1, j-1], C45_0[i-1, j+1], C45_0[i+1, j-1], and C45_0[i+1, j+1]) by the following method-1 or method-2. (Weighted addition is performed on similarity components of a pixel that misses a green color component and its surrounding pixels in a manner shown in Fig. 4(1) or 4(2).)

Page 27, lines 15-19, delete current paragraph and insert therefor:

The operation of the second embodiment will be described below. In the following, the G interpolation processing and the smoothing processing of the image processor 11 will be described with reference to Fig. 8 and the other part of the operation will not be described.

Page 28, lines 1-5, delete current paragraph and insert therefor:

Then, in the same manners as in the first embodiment, the image processor 11 sets, in [i, j], the coordinates of a pixel to be subjected to the G interpolation processing (step S2 in Fig. 8) and calculates a green interpolated value G' [i, j] in accordance with a combination of

the index HV[i, j] indicating vertical and horizontal similarity and the index DN[i, j] indicating diagonal similarity (step S3 in Fig. 8).

Page 28, lines 20-24, delete current paragraph and insert therefor:

That is, the image processor 11 sets a value that is calculated according to Equation (49) as a result of the smoothing processing only for a pixel that is interposed between pixels that are immediately on its left and on its right and in each of which the similarity in the vertical direction and that in the horizontal direction have no substantial difference and diagonal similarities in 45° and 135° have no substantial difference.

Page 29, lines 14-17, delete current paragraph and insert therefor:

That is, the image processor 11 sets a value that is calculated according to Equation (50) as a result of the smoothing processing only for a pixel that is interposed between pixels that are immediately over and under it and in each of which the similarity in the vertical direction and that in the horizontal direction have no substantial difference and diagonal similarities in 45° and 135° have no substantial difference.

Page 29, line 25 to page 30, line 5, delete current paragraph and insert therefor:

As described above, in the second embodiment, a value obtained by performing weighted addition on pieces of color information on green color component in a local area is set as a value indicating a result of the smoothing processing only for pixels each of which are interposed between pixels in each of which the similarity in the vertical direction and that in the horizontal direction have no substantial difference and diagonal similarities in 45° and 135° have no substantial difference among pixels that have color information on green color component.

Page 30, lines 10-15, delete current paragraph and insert therefor:

In the second embodiment, a value calculated according to Equation (49) or (50) is set as a result of the smoothing processing only for pixels each of which are interposed between pixels in each of which the similarity in the vertical direction and that in the horizontal

direction have no substantial difference and diagonal similarities in 45° and 135° have no

substantial difference. Therefore, step S6 in Fig. 3 of the first embodiment for restoring G'[i, j-1] and G'[i-1,j] to the original pieces of color information on green color component is not

necessary.

Page 31, lines 22-25, delete current paragraph and insert therefor:

The operation of the third embodiment will be described below. In the following, the

smoothing processing of the image processor 11 will be described with reference to Fig. 9

and the other part of the operation will not be described.

Page 35, lines 4-12, delete current paragraph and insert therefor:

Incidentally, in Equation (57'), G'[m, n] that is calculated as a result of the smoothing

processing may be calculated by performing weighted addition on not only the pieces of color

information on green color component of the pixels having the coordinates [m-1, n-1], [m, n]

and [m+1, n-1] but also the pieces of color information on green color component of the

pixels having the coordinates [m-1, n+1], [m, n] and [m+1, n+1].

Page 35, lines 13-16, delete current paragraph and insert therefor:

That is, in the present embodiment, a pixel as a subject of smoothing processing is

smoothed by using the color information on green color component of the target pixel itself

and the pieces of color information on green color component of the pixels that are adjacent

to the target pixel and are located in the diagonal directions.

Page 36, lines 13-15, delete current paragraph and insert therefor:

The fourth embodiment corresponds to a case that image processing is performed by

the PC 18 shown in Fig. 1 by using a storage medium in which an image processing program

as recited in the present invention is stored.

Page 36, line 24 to page 37, line 7, delete current paragraph and insert therefor:

When an operator selects a shooting mode and depresses the release button by

manipulating the operation part 24, the electronic camera 1 digitizes, with the A/D converter

10, an image signal that has been generated by the image-capturing sensor 21 and subjected

to prescribed analog signal processing in the analog signal processor 22, and supplies

resulting image data to the image processor 11. The image processor 11 performs, on the

received image data, image processing excluding the interpolation processing and the

smoothing processing (e.g., γ correction). The image data that has been subjected to the

image processing is written to the memory card 16 via the memory card interface 17.

IN THE CLAIMS:

Please replace claims 1-15 as follows:

1. (Amended) An image processing apparatus for smoothing image data that is

formed by a plurality of pixels and includes at least one color component, comprising:

smoothing means for selectively performing, for at least one color component of a

target pixel, smoothing that uses pieces of color information of at least one color component

of the target pixel and of pixels adjacent to the target pixel among a plurality of pixels that

form the image data, the smoothing done in accordance with correlation between the target

pixel and pixels in the vicinity of the target pixel.

2. (Amended) An image processing apparatus for smoothing image data that is

formed by a plurality of pixels and includes at least one color component, comprising:

similarity degree calculating means for calculating similarity degrees indicating

similarity between a target pixel and pixels in the vicinity of the target pixel among a

plurality of pixels that form the image data;

classifying means for classifying pixels whose similarity degrees have been calculated

by the similarity degree calculating means into one of a plurality of groups having different

similarity degree features; and

smoothing means for selecting a pixel to be subjected to smoothing from among a

pixel that has been classified into a particular group in the plurality of groups and pixels in

the vicinity of the pixel that has been classified into the particular group, and *for performing*

smoothing on color information of at least one color component of the selected pixel by using pieces of color information of at least one color component of the selected pixel and of pixels adjacent to the selected pixel.

3.   (Amended) The image processing apparatus according to claim 2, wherein said smoothing means smoothes color information of a color component of a pixel adjacent to a pixel that has been classified into the particular group by the classifying means, and restores into its original state color information of a color component of a smoothed pixel among pixels adjacent to a pixel that has not been classified into the particular group by the classifying means.

4.   (Amended) The image processing apparatus according to claim 3, wherein said smoothing means:

sequentially selects pixels that became subjects of classification by the classifying means;

smoothes color information of a color component of a pixel that is adjacent to not only a pixel selected at an arbitrary time point but also to a pixel that is not selected at the arbitrary time point when the selected pixel is classified into the particular group; and

restores into its original state color information of a color component of a smoothed pixel among pixels adjacent to the pixel selected at the arbitrary time point when the selected pixel is not classified into the particular group.

5.   (Amended) The image processing apparatus according to claim 2, wherein said smoothing means smoothes color information of a color component of a pixel that is adjacent to a plurality of pixels that have been classified into the particular group by the classifying means.

6.   (Amended) The image processing apparatus according to claim 2, wherein said smoothing means uses, as said particular group, a group having a feature that similarity

degrees calculated in at least two different directions by the similarity degree calculating means are approximately the same.

7. (Amended) The image processing apparatus according to claim 6, wherein said smoothing means judges that similarity degrees in at least two different directions are approximately the same when a difference between similarity degrees calculated in the at least two different directions by the similarity degree calculating means is smaller than a prescribed threshold value.

8. (Amended) An image processing apparatus for smoothing image data that is formed by a plurality of pixels and includes at least one color component, comprising:

interpolating means for interpolating pieces of color information of a color component that is absent from pixels that are arranged at a prescribed pitch among pixels that form the image data;

similarity degree calculating means for calculating similarity degrees in at least two different directions for each pixel to be a subject of interpolation by the interpolating means;

classifying means for classifying each of pixels whose similarity degrees have been calculated by the similarity degree calculating means into one of a plurality of groups having different similarity degree features; and

smoothing means for selecting a pixel to be subjected to smoothing from among a pixel that has been classified into a particular group in the plurality of groups and pixels in the vicinity of the pixel that has been classified into the particular group, and for performing smoothing on color information of a color component of the selected pixel by using pieces of color information of color components of the selected pixel and of pixels adjacent to the selected pixel.

9. (Amended) The image processing apparatus according to claim 8, wherein: said smoothing means performs the smoothing parallel with the interpolation by the interpolating means.

10.   (Amended) The image processing apparatus according to claim 8, wherein:

said interpolating means employs, as subjects of the interpolation, pixels that miss a color component having a highest spatial arrangement density; and

said smoothing means smoothes color information of the color component having the highest spatial arrangement density of a pixel adjacent to a pixel that has been classified into the particular group.

11.   (Amended) The image processing apparatus according to claim 8, wherein said smoothing means smoothes color information of a color component of a pixel adjacent to a pixel that has been classified into the particular group by the classifying means, and restores into its original state color information of a color component of a smoothed pixel among pixels adjacent to a pixel that has not been classified into the particular group by the classifying means.

12.   (Amended) The image processing apparatus according to claim 11, wherein said smoothing means:

sequentially selects pixels that became subjects of classification by the classifying means;

smoothes color information of a color component of a pixel that is adjacent to not only a pixel selected at an arbitrary time point but also to a pixel that is not selected at the arbitrary time point when the selected pixel is classified into the particular group; and

restores into its original state color information of a color component of a smoothed pixel among pixels adjacent to the pixel selected at the arbitrary time point when the selected pixel is not classified into the particular group.

13.   (Amended) The image processing apparatus according to claim 8, wherein said smoothing means smoothes color information of a color component of a pixel that is adjacent to a plurality of pixels that have been classified into the particular group by the classifying means.

14.   (Amended) The image processing apparatus according to claim 8, wherein said smoothing means uses, as said particular group, a group having a feature that similarity degrees calculated in at least two different directions by the similarity degree calculating means are approximately the same.

15.   (Amended) The image processing apparatus according to claim 14, wherein said smoothing means judges that similarity degrees in at least two different directions are approximately the same when a difference between similarity degrees calculated in the at least two different directions by the similarity degree calculating means is smaller than a prescribed threshold value.

REMARKS

Claims 1-30 are pending. By this Preliminary Amendment, the title, specification and claims 1-15 are amended. Prompt and favorable examination on the merits is respectfully requested.

The attached Appendix includes marked-up copies of each rewritten paragraph (37 C.F.R. §1.121(b)(1)(iii)) and claim (37 C.F.R. §1.121(c)(1)(ii)).

Respectfully submitted,
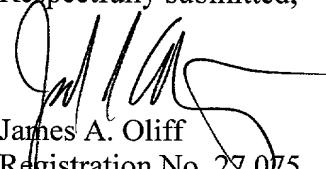
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Attached: APPENDIX
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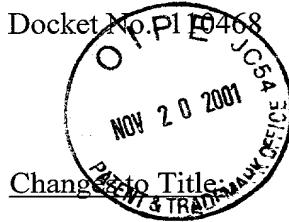
APPENDIX

Changes to Title:

The following is a marked-up version of the amended title:

IMAGE PROCESSING ~~DEVICE~~APPARATUS AND STORAGE MEDIUM FOR

STORING IMAGE PROCESSING PROGRAM

Changes to Specification:

The following are marked-up versions of the amended paragraphs:

Page 1, lines 6-8:

The present invention relates to an image processing ~~device~~apparatus for smoothing

image data and to a storage medium in which an image processing program for causing a

computer to perform such smoothing is stored.

Page 6, lines 4-6:

First to third embodiments are directed to an electronic camera that is provided with a

function of image processing that is performed by an image processing ~~device~~apparatus

according to the invention.

Page 9, lines 11-14:

In the first to third embodiments, a result of G interpolation processing or smoothing

processing is set in G'[X, Y]. It is assumed that color ~~component~~information on the green

color component G[X, Y] is set as an initial value for G'[X, Y] corresponding to a pixel in

which color information on green color component exists.

Page 9, lines 19-22:

The operation of the first embodiment will be described below. In the following, the

G interpolation processing and the smoothing processing of the image processor 11 will be

described with reference to Fig. 3 and the other part of the operation will not be described.

~~The first embodiment corresponds to claims 1, 2, 5-10, 12, and 13.~~

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Page 18, lines 2-9:

Specifically, the image processor 11 calculates a similarity degree C45Cv[i, j] in the diagonal 45° direction and a similarity degree C135Ch[i, j] in the diagonal 135° direction of a pixel that misses a green color component by performing weighted addition on results of weighted addition on similarity components of the pixel that misses a green color component and its surrounding pixels (e.g., C45_0[i, j], C45_0[i-1, j-1], C45_0[i-1, j+1], C45_0[i+1, j-1], and C45_0[i+1, j+1]) by the following method-1 or method-2. (Weighted addition is performed on similarity components of a pixel that misses a green color component and its surrounding pixels in a manner shown in Fig. 4(1) or 4(2).)

Page 27, lines 15-19:

The operation of the second embodiment will be described below. In the following, the G interpolation processing and the smoothing processing of the image processor 11 will be described with reference to Fig. 8 and the other part of the operation will not be described. ~~The second embodiment corresponds to claims 1, 2, 5-8, and 11-13.~~

Page 28, lines 1-5:

Then, in the same manners as in the first embodiment, the image processor 11 sets, in [i, j], the coordinates of a pixel to be subjected to the G interpolation processing (step S2 in Fig. 8) and calculates a green interpolated value G'_[i, j] in accordance with a combination of the index HV[i, j] indicating vertical and horizontal similarity and the index DN[i, j] indicating diagonal similarity (step S3 in Fig. 8).

Page 28, lines 20-24:

That is, the image processor 11 sets a value that is calculated according to Equation (49) as a result of the smoothing processing only for a pixel that is interposed between pixels that are immediately on its left and on its right and in each of which the similarity in the

A-2

vertical direction and that in the horizontal direction have no substantial difference and diagonal similarities in 45° and 135° have no substantial difference.

Page 29, lines 14-17:

That is, the image processor 11 sets a value that is calculated according to Equation (50) as a result of the smoothing processing only for a pixel that is interposed between pixels that are immediately over and under it and in each of which the similarity in the vertical direction and that in the horizontal direction have no substantial difference and diagonal similarities in 45° and 135° have no substantial difference.

Page 29, line 25 to page 30, line 5:

As described above, in the second embodiment, a value obtained by performing weighted addition on pieces of color information on green color component in a local area is set as a value indicating a result of the smoothing processing only for pixels each of which are interposed between pixels in each of which the similarity in the vertical direction and that in the horizontal direction have no substantial difference and diagonal similarities in 45° and 135° have no substantial difference among pixels that have color information on green color component.

Page 30, lines 10-15:

In the second embodiment, a value calculated according to Equation (49) or (50) is set as a result of the smoothing processing only for pixels each of which are interposed between pixels in each of which the similarity in the vertical direction and that in the horizontal direction have no substantial difference and diagonal similarities in 45° and 135° have no substantial difference. Therefore, step S6 in Fig. 3 of the first embodiment for restoring G'[i, j-1] and G'[i-1,j] to the original pieces of color information on green color component is not necessary.

Page 31, lines 22-25:

The operation of the third embodiment will be described below. In the following, the smoothing processing of the image processor 11 will be described with reference to Fig. 9 and the other part of the operation will not be described. ~~The third embodiment corresponds to claims 1-4, 12, and 13.~~

Page 35, lines 4-12:

Incidentally, in <u>Equation (57')</u>~~each of the first and second embodiments~~, G'[m, n~~i+1,~~ j] that is calculated as a result of the smoothing processing may be calculated by performing weighted addition on not only the pieces of color information on green color component of the pixels having the coordinates <u>[m-1, n-1], [m, n] and [m+1, n-1]</u>~~[i, j-1], [i+1, j], and [i, j+1]~~ but also the pieces of color information on green color component of the pixels having the coordinates <u>[m-1, n+1], [m, n] and [m+1, n+1]</u>.~~[i+2, j-1] and [i+2, j+1]. Similarly, G'[i, j+1] may be calculated by performing weighted addition on not only the pieces of color information on green color component of the pixels having the coordinates [i-1, j], [i, j+1], and [i+1, j] but also the pieces of color information on green color component of the pixels having the coordinates [i-1, j+2] and [i+1, j+2].~~

Page 35, lines 13-16:

That is, in the <u>present embodiment</u>~~invention~~, a pixel as a subject of smoothing processing is smoothed by using the color information on green color component of the target pixel itself and the pieces of color information on green color component of the pixels that are adjacent to the target pixel and are located in the diagonal directions.

Page 36, lines 13-15:

The fourth embodiment corresponds to a case that image processing is performed by the PC 18 shown in Fig. 1 by using a storage medium in which an image processing program as recited in <u>the present invention</u>~~any of claims 14-16~~ is stored.

Page 36, line 24 to page 37, line 7:

When an operator selects a shooting mode and depresses the release button by manipulating the operation part 24, the electronic camera 1 digitizes, with the A/D converter 10, an image signal that has been generated by the image-capturing sensor 21 and subjected to prescribed analog signal processing in the analog signal processor 22, and supplies resulting image data to the image processor 11. The image processor 11 performs, on the received image data, image processing excluding the interpolation processing and the smoothing processing (e.g., γ correction ~~and edge enhancement~~). The image data that has been subjected to the image processing is written to the memory card 16 via the memory card interface 17.

Changes to Claims:

The following are marked-up versions of the amended claims:

1.   (Amended) An image processing apparatus~~device~~ for smoothing image data that is formed by a plurality of pixels and includes at least one color component, comprising:

smoothing means for selectively performing, for at least one color component of a target pixel, smoothing that uses pieces of color information of at least one color component of the target pixel and of pixels adjacent to the target pixel among a plurality of pixels that form the image data, the smoothing done in accordance with correlation between the target pixel and pixels in the vicinity of the target pixel.

2.   (Amended) An image processing apparatus~~device~~ for smoothing image data that is formed by a plurality of pixels and includes at least one color component, comprising:

similarity degree calculating means for calculating similarity degrees indicating similarity between a target pixel and pixels in the vicinity of the target pixel among a plurality of pixels that form the image data;

classifying means for classifying pixels whose similarity degrees have been calculated

by the similarity degree calculating means into one of a plurality of groups having different

similarity degree features; and

smoothing means for selecting a pixel to be subjected to smoothing from among a

pixel that has been classified into a particular group in the plurality of groups and pixels in

the vicinity of the pixel that has been classified into the particular group, and for performing

smoothing on color information of at least one color component of the selected pixel by using

pieces of color information of at least one color component of the selected pixel and of pixels

adjacent to the selected pixel.

3.   (Amended) The image processing apparatus~~device~~ according to claim 2,

wherein said smoothing means smoothes color information of a color component of a pixel

adjacent to a pixel that has been classified into the particular group by the classifying means,

and restores into its original state color information of a color component of a smoothed pixel

among pixels adjacent to a pixel that has not been classified into the particular group by the

classifying means.

4.   (Amended) The image processing apparatus~~device~~ according to claim 3,

wherein said smoothing means:

sequentially selects pixels that became subjects of classification by the classifying

means;

smoothes color information of a color component of a pixel that is adjacent to not

only a pixel selected at an arbitrary time point but also to a pixel that is not selected at the

arbitrary time point when the selected pixel is classified into the particular group; and

restores into its original state color information of a color component of a smoothed

pixel among pixels adjacent to the pixel selected at the arbitrary time point when the selected

pixel is not classified into the particular group.

5.   (Amended) The image processing apparatus~~device~~ according to claim 2, wherein said smoothing means smoothes color information of a color component of a pixel that is adjacent to a plurality of pixels that have been classified into the particular group by the classifying means.

6.   (Amended) The image processing apparatus~~device~~ according to claim 2, wherein said smoothing means uses, as said particular group, a group having a feature that similarity degrees calculated in at least two different directions by the similarity degree calculating means are approximately the same.

7.   (Amended) The image processing apparatus~~device~~ according to claim 6, wherein said smoothing means judges that similarity degrees in at least two different directions are approximately the same when a difference between similarity degrees calculated in the at least two different directions by the similarity degree calculating means is smaller than a prescribed threshold value.

8.   (Amended) An image processing apparatus~~device~~ for smoothing image data that is formed by a plurality of pixels and includes at least one color component, comprising:

interpolating means for interpolating pieces of color information of a color component that is absent from pixels that are arranged at a prescribed pitch among pixels that form the image data;

similarity degree calculating means for calculating similarity degrees in at least two different directions for each pixel to be a subject of interpolation by the interpolating means;

classifying means for classifying each of pixels whose similarity degrees have been calculated by the similarity degree calculating means into one of a plurality of groups having different similarity degree features; and

smoothing means for selecting a pixel to be subjected to smoothing from among a pixel that has been classified into a particular group in the plurality of groups and pixels in

the vicinity of the pixel that has been classified into the particular group, and for performing

smoothing on color information of a color component of the selected pixel by using pieces of

color information of color components of the selected pixel and of pixels adjacent to the

selected pixel.

9.   (Amended) The image processing apparatus~~device~~ according to claim 8,

wherein: said smoothing means performs the smoothing parallel with the interpolation by the

interpolating means.

10.   (Amended) The image processing apparatus~~device~~ according to claim 8,

wherein:

said interpolating means employs, as subjects of the interpolation, pixels that miss a

color component having a highest spatial arrangement density; and

said smoothing means smoothes color information of the color component having the

highest spatial arrangement density of a pixel adjacent to a pixel that has been classified into

the particular group.

11.   (Amended) The image processing apparatus~~device~~ according to claim 8,

wherein said smoothing means smoothes color information of a color component of a pixel

adjacent to a pixel that has been classified into the particular group by the classifying means,

and restores into its original state color information of a color component of a smoothed pixel

among pixels adjacent to a pixel that has not been classified into the particular group by the

classifying means.

12.   (Amended) The image processing apparatus~~device~~ according to claim 11,

wherein said smoothing means:

sequentially selects pixels that became subjects of classification by the classifying

means;

smoothes color information of a color component of a pixel that is adjacent to not

only a pixel selected at an arbitrary time point but also to a pixel that is not selected at the

arbitrary time point when the selected pixel is classified into the particular group; and

restores into its original state color information of a color component of a smoothed

pixel among pixels adjacent to the pixel selected at the arbitrary time point when the selected

pixel is not classified into the particular group.

13.   (Amended) The image processing apparatus~~device~~ according to claim 8,

wherein said smoothing means smoothes color information of a color component of a pixel

that is adjacent to a plurality of pixels that have been classified into the particular group by

the classifying means.

14.   (Amended) The image processing apparatus~~device~~ according to claim 8,

wherein said smoothing means uses, as said particular group, a group having a feature that

similarity degrees calculated in at least two different directions by the similarity degree

calculating means are approximately the same.

15.   (Amended) The image processing apparatus~~device~~ according to claim 14,

wherein said smoothing means judges that similarity degrees in at least two different

directions are approximately the same when a difference between similarity degrees

calculated in the at least two different directions by the similarity degree calculating means is

smaller than a prescribed threshold value.